The 2dF Redshift Survey II: UGC 8584 - Redshift Periodicity and Rings

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ABSTRACT

UGC 8584 was selected by a computer program as having a number of quasars around it that obeyed the Karlsson periodicity in its reference frame. On closer examination 9 of the nearest 10 quasars turned out to be extremely close to the predicted values. Also it turned out that UGC 8584 was a disturbed triple galaxy and a strong triple radio source as well as being a strong millimeter and infrared source. Evidence for present ejection velocities of $z_v \sim .01$ for the associated quasars is present and some pairing of ejections is noted.

A new and important result emerges from this sample of galaxy/quasar families, namely that rings and shells of galaxies and quasars tend to surround galaxies which have active nuclei. Test cases suggest obscuration of the background around these galaxies out to about $20'$ or beyond. Because incidents of strong reddening are not observed, obscuring particles are suggested to be large compared to optical wavelengths. In principle, material ejected with the quasars could be of sizes of gravel, boulders or larger.

Subject headings: galaxies: active - galaxies: individual (UGC 8584) - quasars: general - radio continuum: general

1. Introduction

In a computer analysis of the 2dF redshift survey, groups of quasars that obeyed the Karlsson values with respect to neighboring galaxies were catalogued in Fulton & Arp (2006) (Paper I). UGC 8584 turned out to have 9 of its nearest quasars fall especially close to the standard Karlsson values. Figure 1 and Table 1 show that 9 of the nearest 10 have an average periodicity residual of only $|z_v| \geq .010$. Since there is a range of about .105 between adjacent periodicity peaks in z_v, each of these z_v's has a chance of about $z_v/.0525$ of being accidental. The highest z_v of the first 9 is .0165. Therefore the chance of 9 of the first 10 falling by accident this closely to the peaks is

$$P = 10!/9! \times 0.29^9 \times .72 = 1.0 \times 10^{-4}$$

The effect shown in Figure 1 is so strong that the cumulative average z_v never reaches its expected value of .0525 for random z's even at the edge of the field ($r = 30'$). For this particular galaxy-quasar family then

there appears to be strong evidence that the quasar redshifts obey the Karlsson series first annunciated in 1971 (Karlsson 1971).

Table 1: Quasars Near UGC 8584

Object	z	r'	z_0	z_v
UGC 8584	0.060	0.0	...	...
2QZ	1.583	3.4	1.44	$+.011^a$
2QZ	.714	7.5	.62	$+.011^a$
2QZ	2.168	8.4	1.99	$+.010^a$
SDSS	1.807	8.9	1.65	$+.099^b$
2QZ	1.542	10.4	1.40	$-.005^a$
LBQS	.672	12.0	.58	$-.014^a$
2QZ	.668	15.0	.57	$-.017^a$
LBQS	2.800	15.7	2.59	$-.015^a$
2QZ	2.189	16.5	2.01	$+.016^a$
SDSS	.702	16.7	.61	$+.003^{ab}$
2QZ	2.547	17.4	2.35	-.09
2QZ	2.168	19.8	1.99	+.01
2QZ	1.918	20.6	1.75	-.07
SDSS	2.027	21.5	1.86	-.03
2QZ	.687	23.6	.59	-.01
2QZ	.829	23.9	.73	+.08
2QZ	1.504	27.1	1.36	-.02
SDSS	1.858	28.6	1.70	-.09
2QZ	1.646	28.6	1.50	+.04
2QZ	2.438	28.8	2.24	+.10
2QZ	.939	28.8	.83	-.07
2QZ	2.277	29.4	2.09	+.04
2QZ	2.093	29.4	1.92	-.01

$$(1 + z_Q)/(1 + z_G) = (1 + z_0)$$

$$(1 + z_O)/(1 + z_K) = (1 + z_v)$$

G = galaxy, K = Karlsson, Q = quasar

z_0 = transformed Q to G

$z_v = z_Q$ seen from Galaxy

[a] The highest z_v of the first 9 of 10 quasars is .0165.

[b] Figures 1 and 3 were made up from an early version of NED data. Later two additions were made from SDSS, quasars of $z = 1.807$ and .702 having $z_v = +.097$ and $+.003$. Table 1 shows these new entries. The probabilities were calculated from Table 1. The difference in the cumulative means of Figure 1 is not significant and is consistent with considering the $z = 1.807$ as a non associated interloper or a z value falling briefly between two peaks.
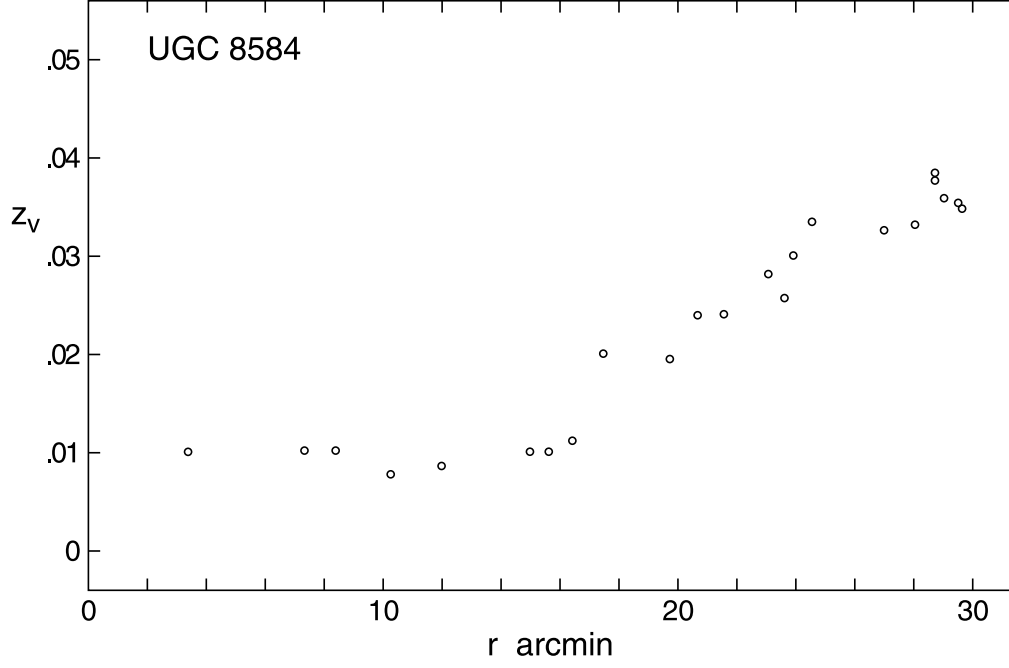
Fig. 1.— z_v's represent cumulative average residuals from Karlsson periodicity peaks. Of the first 10 quasars out to $r = 16.5'$, 9 are very close to Karlsson periodicities. See footnotes to Table 1.
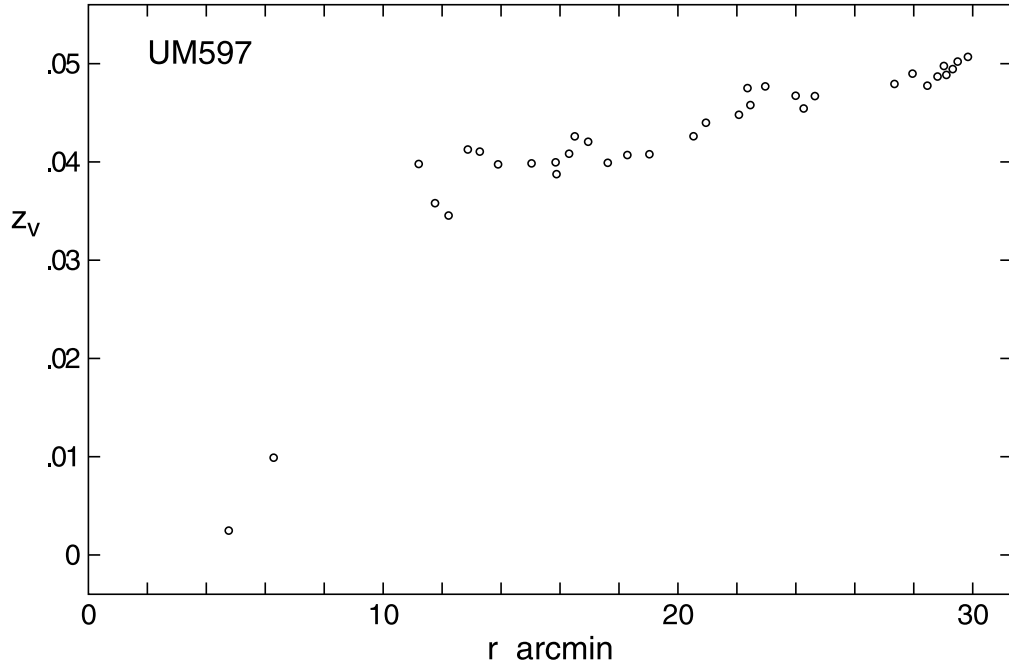

Fig. 2.— As above, z_v's represent cumulative residuals from Karlsson periodicity peaks. The first two quasars are very close to this particular parent and to the Karlsson peak at z = 1.96.

To make a visual comparison with another field, Figure 2 is shown just below UGC 8584. In the case of the active galaxy UM 597 the two nearest quasars are very closely periodic in redshift ($z_0 = 1.97$ and 1.91) and within $6.7'$ in distance. But then a large number of quasars set in with large cumulative z_v averages at greater than about $12'$. In both plots if the quasars were not near their periodic redshift values the lines of points would run straight across at a cumulative average of about $z_v = .0525$. (With larger scatter at small r.) The actual plots show the effect of quasars matching the periodic values strongly close to the parent galaxies, but still affecting the plots out past $r = 30'$.

2. Evidence for Ejection

Another way of analyzing the periodicity residuals for the quasars within $30'$ of UGC 8584 is shown in Figure 3. The histogram shows a symmetrical distribution around zero. There is a strong excess within $z_v = \pm.03$. If the expected background is taken from the wings of the histogram this indicates a peak of about 4 sigma significance.

Also important, however, is the fact that the largest concentration of residuals is at $-.01$ and again at $+.01$. This would be strong evidence for an ejection velocity of the order of $v = .01c$ with equal numbers toward and away from the observer. It would be difficult to imagine a more direct proof of ejection.
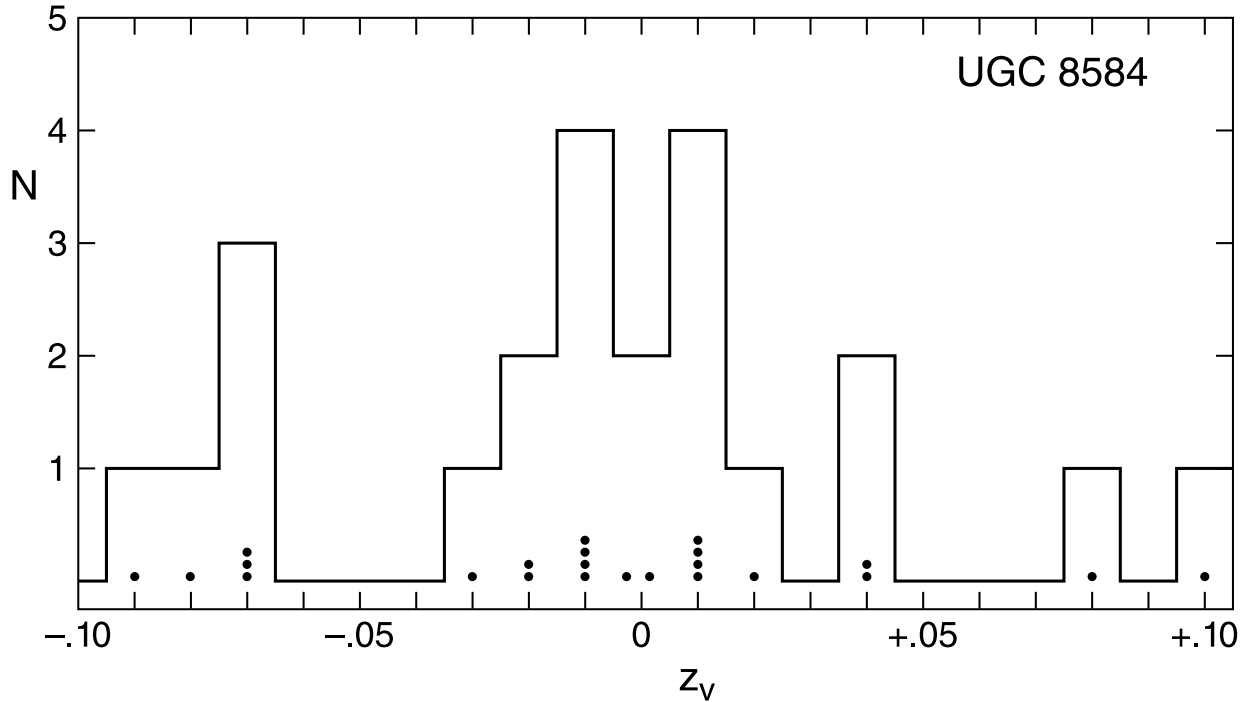

Fig. 3.— Distribution of periodicity residuals, z_v.

3.   The Disturbed Morphology of UGC 8584

UGC 8584 is a distorted triple system of about 15 mag. as shown here in Figure 4. All three objects have $z = .060$. In the high resolution FIRST measures each of these is shown to be a compact radio source with the central one the brightest. It is difficult to escape the conclusion that the two flanking objects are portions of the central galaxy torn off or entrained in an ejection event.
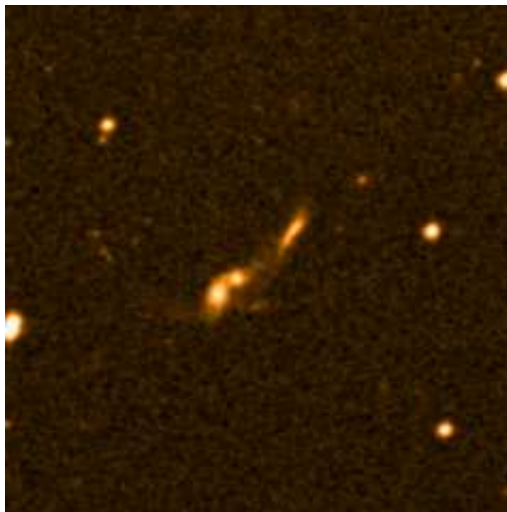

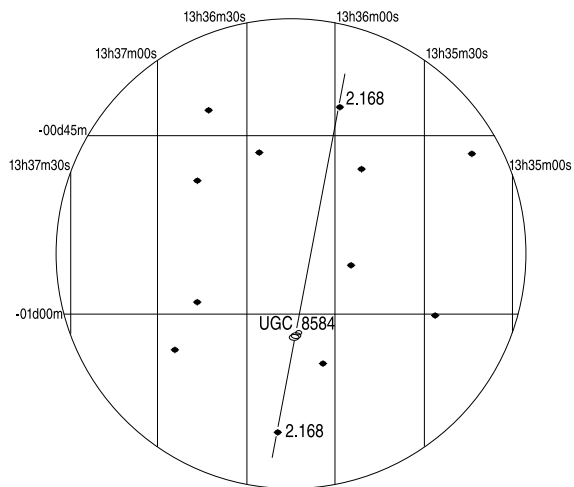Fig. 4.— Digital Sky Survey blue image of triple system UGC 8584.

Fig. 5.— Quasars within $20'$ of UGC 8584 showing pair at $z = 2.168$.

4. Evidence for Radio Ejection from UGC 8584

The relation between ejection of radio sources and ejection of quasars has long been apparent (e.g. Arp (1966), Arp (2003)). In the case of UGC 8584 the fact that the central galaxy in the association of quasars was bright and violently disturbed supports the inference of origin from, and physical association with, UGC 8584. As Figure 6 here shows, UGC 8584 is also itself a strong radio source, reinforcing the aspect of activity of the source of the associated quasars.

But something else of great interest appears in Figure 6. UGC 8584 seems to be in the center of a ring of bright radio sources. There are radio sources outside this ring but the interesting feature is that radio sources appear to be cleared out of a circle of radius about 13′ around UGC 8584. If there has been violent ejection from the central galaxy it is reasonable to suppose that most of the low density radio plasma has been pushed outward leaving a radio source free cavity.
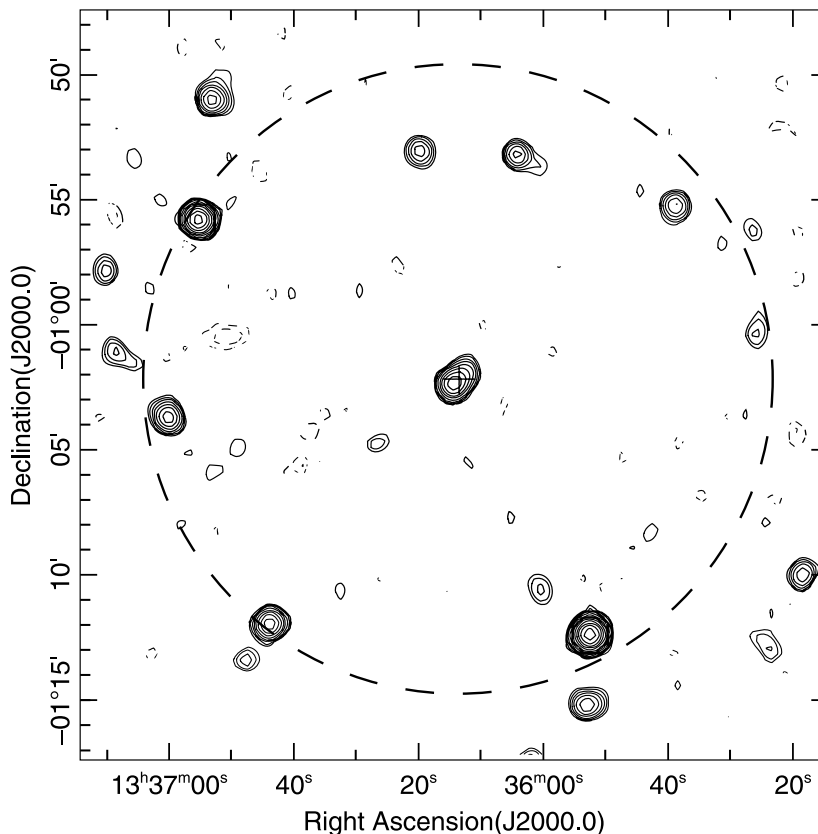

Fig. 6.— NVSS radio map centered on UGC 8584. Dashed circle = 13′ radius.

5.   Obscuring Material Ejected?

It is clear from Figure 1 that inside about 20′ from UGC 8584 that the quasars all fall extremely close to Karlsson redshift peaks. Figure 7 here shows this in a sightly different way that emphasizes the result that inside about 20′ there are almost no quasars that do not obey the Karlsson Peaks. This is strong support for the physical association of these quasars with UGC 8584. But the question then rises: where is the background of non-associated sources?

On average for 2dF quasars we expect 33 QSOs/sq.deg. But Figure 7 shows that for non associated quasars near UGC 8584 the density is low, between 3 and 6/sq.deg. By 37′ the density above $z_v \geq .01$ in Figure 7 already reaches about 27/sq.deg. It seems strongly indicated that a background of quasars near UGC 8584 is being obscured. Although this should be checked, there seems to be no conspicuous reddening involved. If so the particle sizes would be larger than dust, perhaps gravel, boulder or larger sizes.
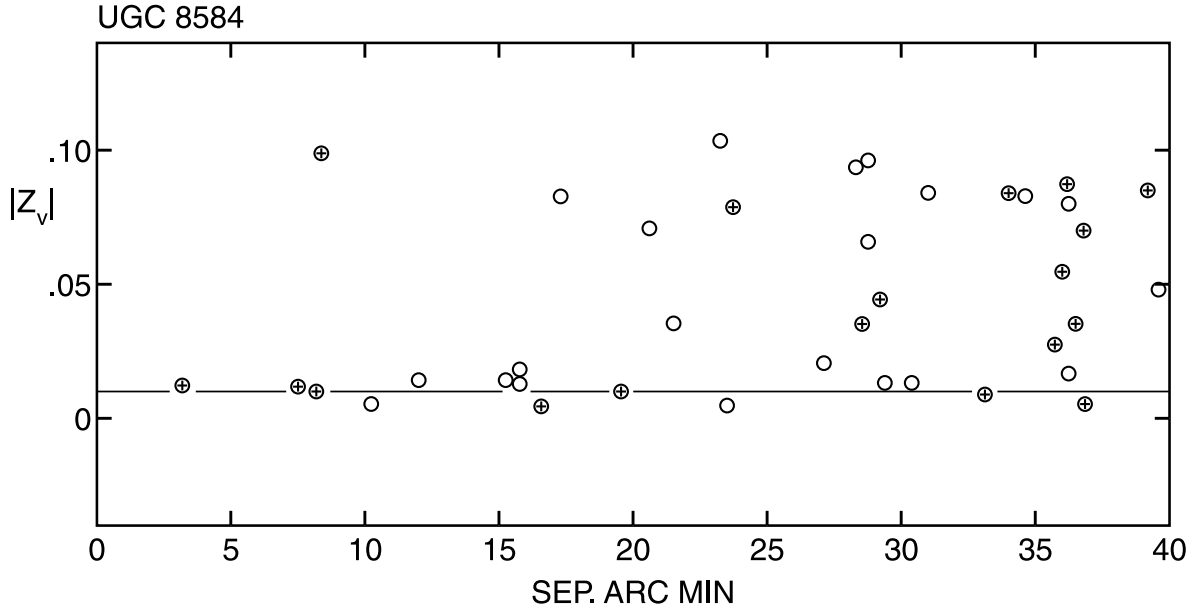

Fig. 7.— Residuals from Karlsson Peaks for redshifts of quasars (z_v) as a function of separation from UGC 8584. Plus and minus residuals labeled. Note that the almost exact correspondence with periodicity peaks is NOT followed by quasars at greater radial distances.

Altogether with nine of the nearest ten quasars matching so closely the periodicity peaks, the disrupted, active nature of the central galaxy and the ring of radio sources around it, it would seem difficult to avoid the conclusion that 9 of the nearest 10 quasars are physically associated with, and probably ejected from, UGC 8584. The symmetry of the plus and minus residuals in Figure 3 most simply reflects the remains of the original velocities of ejection in opposite directions.

That the ejection takes place in a ring or shell is now supported in several other cases which we briefly discuss.

6.   The Ring of Objects Around ESO413-007

It is helpful that there is another parent galaxy in the current sample that has a similar, confirming perimeter of radio sources around it. (This further example was discovered in the same test sampling of a dozen or so of bright galaxy/quasar families as found in the computer analyses of this paper series). Figure 8 shows that there is a ring of objects around the central galaxy ESO413-007 - objects which turn out to be both galaxies and quasars of different redshift values.
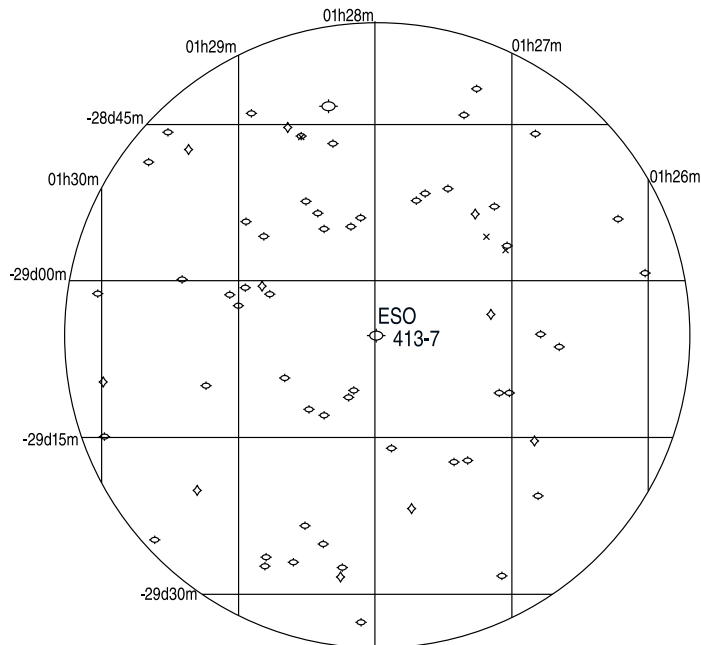

Fig. 8.— Simbad map of extragalactic objects (both galaxies and quasars) within 30′ of ESO413-7.

Figure 8 also shows that the immediate area around the bright (15.8 mag.) infrared galaxy ESO 413-7 is devoid of both galaxies and quasars. To see the radio sources we refer to Figure 9. Like UGC 8584 (compare Figures 6 and 9) there is a loose ring of bright radio sources around the central galaxy and an empty region bordered by radio and optical sources. In order to demonstrate this ring of mixed radio and optical sources we have plotted together in Figure 9 the objects classified as galaxies as ovals and the QSO's as ovals with a dot in the center. Why do they confirm the same hollow ring pattern as the radio sources?

What Figures 5 - 9 suggest is that the ejection activity of the central galaxy has blown a lower density cavity around itself. When the ejected quasar/plasmoids hit the higher density ring or shell the lower density radio plasma is slowed or stopped and in any case stripped from the optical quasar. The optical quasar remains to evolve into a medium redshift galaxy relatively near the observed edge. (These higher redshift companions may also eject radio sources intermittently.)

An interesting side note to Figure 9 is that the nearest quasars (SE of the central ESO galaxy) do not fall at Karlsson Peaks in its $z = .005$ rest frame. But the nearest NED galaxies, SE, at 18.06 and 18.35 mag are infrared (IrS) sources, only 3.7′ and 4.6′ away and just the kinds of galaxies preferentially found as parents of families of associated quasars. As Table 2 shows, for galaxies at $z = 0.101$ and 0.132, five of these quasars fall exceptionally close to the Karlsson peaks!

Table 2: Quasars Near ESO 413-007

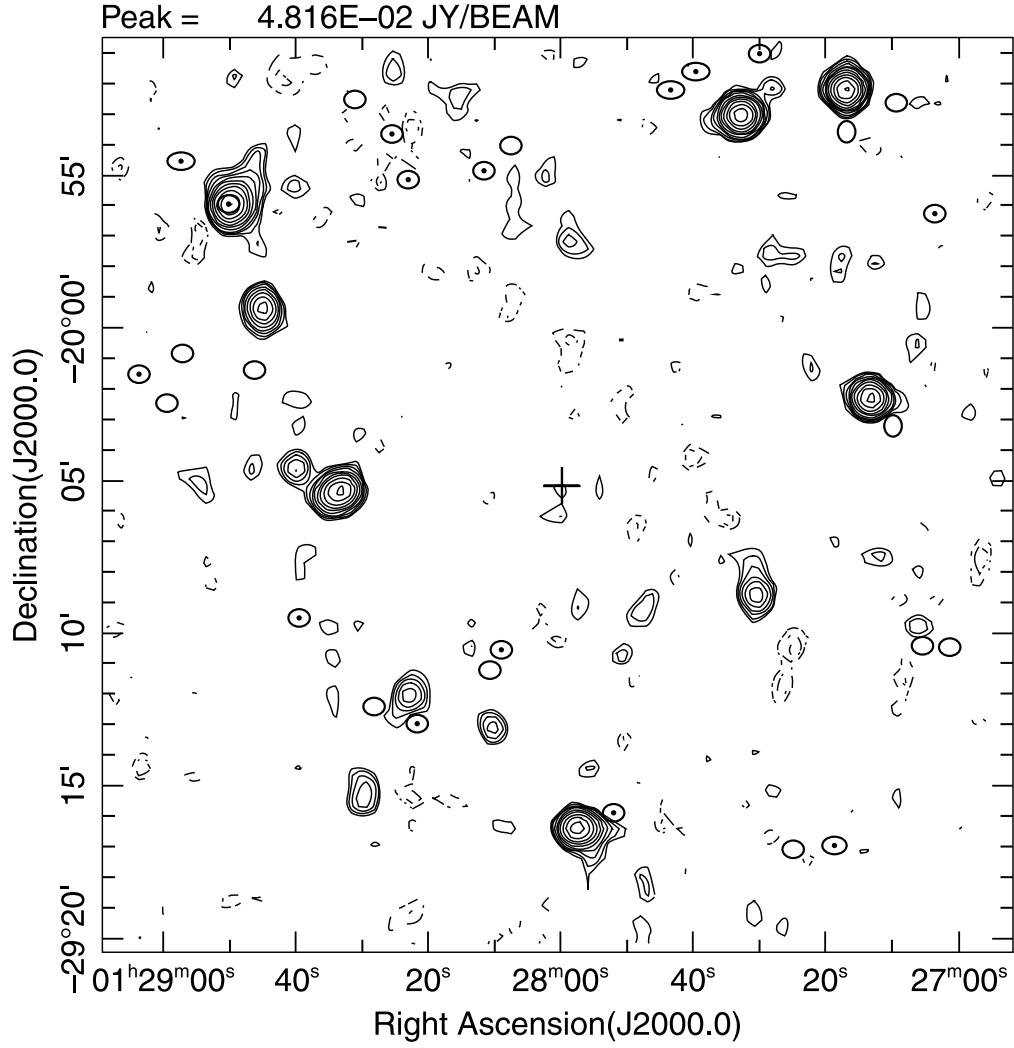| Object	z	z_0	z_v
compn1	0.101	...	...
2QZ	1.675	1.430	+.008
2QZ	1.186	.985	+.013
2QZ	1.168	.969	+.005
compn2	0.132	...	...
2QZ	2.374	1.981	+.007
2QZ	1.186	.931	-.015

Fig. 9.— NVSS radio map in $30 \times 30'$ square around ESO413-7. Ovals represent galaxies and ovals with dots in center represent quasars.

7. Small Ring of Optical Galaxies

A serendipitous example of a ring of optical galaxies is shown in Figure 10. In examining a group of galaxies NW of NGC 4410 (Arp et al. 2007) an SDSS picture of an 18.4g, $z = .089$ galaxy was encountered. As is in Figs. 6 and 8, there is an almost complete circle of galaxies, particularly faint ones, at a radius of about 0.9′. Because there has been no systematic search for such examples, and in view of the evidence for rings in the previous two cases just discussed we would have to conclude there could be many further examples to be discovered. In this case the the two pairs of diametrically opposed blue objects have not been checked with spectra. It would be important if they turned out to be higher redshift AGNs.
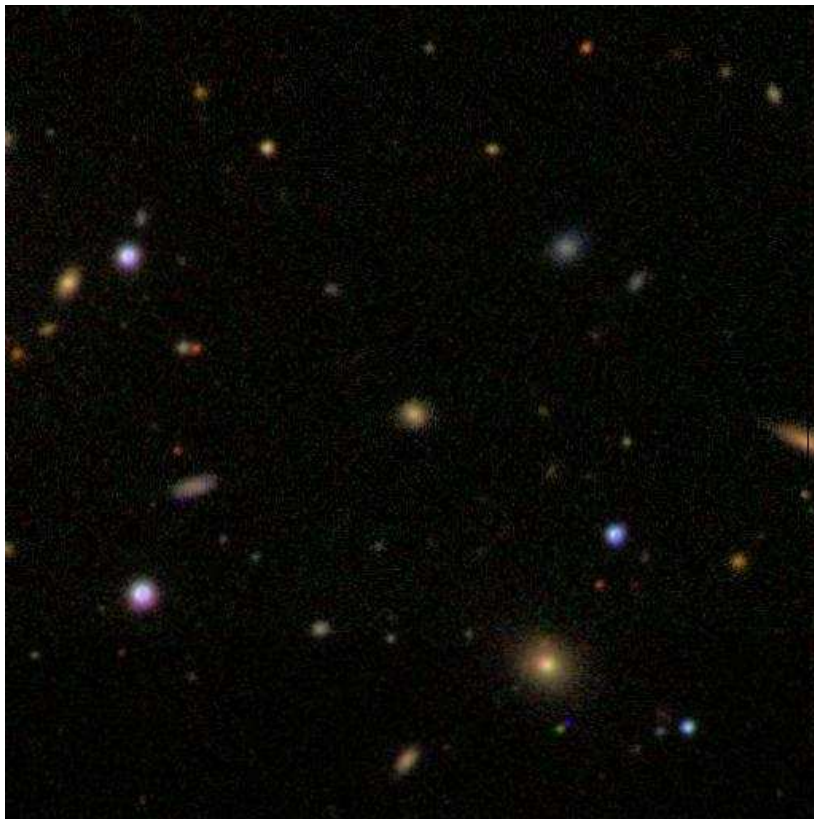

Fig. 10.— An SDSS image of a 3.4′ field around SDSS 122524.87+092307.1. The ring of faint objects has a radius of about 0.9′ around the 18.4g mag. galaxy.

8. Ejection Pairing

Figure 5 shows the Simbad map of the quasars around UGC 8584. The most striking feature is the pair of quasars of exactly the same red shift $z = 2.168$ paired as exactly as can be determined across the central distorted triplet. Certainly this speaks for an ejection origin as so many other equal pairs across active galaxies (vide Arp 220.) Also there seems to be a ring of radio sources about 15′ radius around UGC 8584 as shown in Figure 6.

9. Summary

In a preliminary sampling, one of the quasar families found in the periodicity analysis of Paper I shows nine out of ten of the quasars out to $17'$ to be associated with UGC 8584. When transformed to the rest frame of the disturbed triple radio galaxies that make up UGC 8584, they have redshifts that fall unusually close to the Karlsson peak redshifts. This is like a key fitting into a lock.

Analysis of the residuals from the exact Karlsson peaks shows a symmetrical balance of plus and minus residuals at about $|z_v| = .01c$. This points strongly to their ejection velocity toward and away from the observer at this point in their evolution to smaller intrinsic redshifts.

A ring of radio sources around UGC 8584 at about $r = 13'$ suggests a shell of material has been blown out of the central galaxy during the ejection of the quasars. Another quasar family, UM 597, supports this ring configuration of radio sources and suggests that quasar evolution into galaxies takes place at or near these perimeters. (See e.g. "Origin of Companion Galaxies" in Arp (1998a)).

In turn this suggests that the so called gravitational arcs could represent optical shells that were ejected along with the quasars. Arguments have been made (Arp (1998b); Arp (2003)) that such optical, explosion related, arcs have already been observed.

10. Acknowledgments

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